English geologist, Mr. Thomas Belt, this legend may have had some foundation in the former existence of a continent, now submerged beneath the Caribbean sea, through which the peaks represented by the Lesser Antilles, constituted a mountain chain. Local disturbances have certainly affected this area, but we fail to find any evidence of corresponding disturbance in the Cretaceous strata of our southern States, except perhaps in continental elevations and depressions. Messrs. Guppy, Gabb, and others have studied the rocks of the region, but, up to this time, no one trained to the examination of the difficult phenomena and problems under discussion.

Nov. 14, 1881.

The President, Dr. J. S. Newberry, in the chair. Twenty-four persons present.

A paper was read by Dr. Alexis A. Julien on

THE EXCAVATION OF THE BED OF THE KAATERSKILL, N. Y.

(ABSTRACT.)

This paper was supplementary to one read before the Academy two years ago, concerning the phenomena of erosion, glaciation, etc., in the Catskill Mountains, in the vicinity of the Kaaterskill Clove.

Flexure of Strata.—Prof. James Hall has indicated the existence of four lines of flexure, running from N.E. to S.W., the synclinals occupying the summits of ranges, and Prof. Arnold Guyot locates one of these at Slide Mt. The dips at the entrance of the Clove vary from 8° to 10° to the W. N.W., becoming only 3° four miles to the westward, *i. e.*, more nearly horizontal towards a shallow synclinal fold supposed to occupy Hunter Mt.

One of the most interesting discoveries of Guyot was the linear series of three maxima of altitudes above 4000 feet, Slide Mt., Hunter Mt. and Black Dome. The gentle flexure of the whole stratum required to produce this line of maxima may be thus shown in the range running S.E. and N.W. through Hunter Mt., 35 miles long. Toward the S.E., the descent from the crest of Hunter Mt. (Alt., 4038 feet), to Overlook Mt. (3150 feet), is 888 feet, in 9½ miles, equivalent to 1 in 56, or about 1°; toward the N.W., from Hunter Mt. to Utsyanthe Mt. (3203 feet) the descent is 835 feet in 25 miles, equivalent to 1 in 158, or less than ½°.

Another similar series of maxima, however, occurs further to the westward, consisting of Graham Mt. (3886 feet), Bear-pen Mt. (3545 feet), and Ashland Pinnacle (3420 feet), distant respectively 9, 12, and 15 miles westward of the former series. This southward convergence of the axes of these two folds may probably account for the increased protuberance and greater elevations in the Southern Catskills.

Newly determined altitudes.—Many new determinations have been made of points in the vicinity of the Clove by means of an excellent aneroid, with constant reference to the numerous stations in the vicinity whose altitudes have been accurately obtained by Guyot. A few are here subjoined:

	Feet.
Hotel Kaaterskill, on South Mt.	2466
Parker Hill, summit	2565
Parker Mt., "high ledge."	2874
Clifton House	2101
Newman's ledge, on North Mt.	2486
Gap between E. and W. peaks, North Mt.	3116
Toll-gate on Mt. House road	760

Glaciation of summits.—All the crests near the Clove have been now examined. On none above an altitude of 2900 feet have glacial striæ been found, in part because they consist of thinly laminated flags deeply disintegrated by frosts. The highest striæ discovered were found on Parker Mt., "High ledge" (2874 feet), running S. 18° W. (magnetic), and under the roots of a large tree on the SE. slope of Round Top, at an elevation of 2871 feet, running S. 35° E. However, in all cases, a marked difference exists in the slope of different sides of a peak, the E. and S.E. sides presenting a precipitous face, and the other sides more or less of a gentle slope.

The highest striæ yet found in the Catskills occur on Overlook Mt., at an elevation of about 3100 feet, implying a depth of ice in the Hudson river glacier of about or at least 3200 feet. Within the Kaaterskill basin, several miles distant from the Hudson valley, the overflowing ice stream became shallower, having an altitude of about 3000 feet. It thus appears that the surface of the glacier inclined westward over these mountains, with a slope of 200 feet in 3 miles, 1 in 84, say about ½°.

The conclusions of the former paper have been confirmed by recent observation, viz., that two glacier streams have swept over these mountains, the Continental Glacier from the N. W., submerging and carving out the highest peaks, and the Hudson Valley Glacier from the N., later, more shallow, bearing along vast quantities of materials derived from the crystalline and lower Silurian rocks of the Adirondacks and of the Helderberg Mts., and strewing the whole region with their boulders; and that no local glaciers have existed in the Catskills after the retreat of the Hudson Valley Glacier.

Tilting of the Catskill plateau.—In the previous paper an explanation had been given of certain facts which seemed to indicate that the whole formation had been gently inclined to the East and then to the South-east, before assuming its present W. N. W. inclination, at a period far anterior to the Glacial epoch. A profile section of the ancient Kaaterskill valley, was exhibited, reaching from Haines' Falls nearly to the junction of the N. and S. branches of Schoharie creek, proving the gentleness of the slope, the absence of rock, and the existence of a deep and narrow buried cañon, now filled up with moraine material and a capping of peat.

A comparison of the altitudes of Prattsville (1164 ft.), a point on the Western axis, 12 miles distant from the Kaaterskill Clove, and of the lip of the stratum above Haines' Falls, (1857 ft.), at the head of the Clove, shows that a depression of the latter point below a line connecting these two points, even to the extent of a single degree, would cause a descent of nearly 700 feet from Prattsville to Haines' Falls, *i. e.*, toward the East. The excavation of the deep Kaaterskill and Plaaterkill Cloves could hardly have been effected by the small streams now occupying their beds. It is more probable that the Schoharie creek formerly flowed, at a higher level, to the east into the Kaaterskill Clove, and afterwards to the southeast into the Plaaterkill Clove, before the latest tilting of the plateau to the W. N. W. caused a reversal of the flow of the stream, in the very opposite direction, through the greater part of the same valley. An objection to this theory presented itself in the obstacle which has created a turn to the S. W. in the North branch of Schoharie creek, near its junction with the South branch. But on recent examination this was found to consist not of rock but of a huge mass of coarse moraine material deposited during the Glacial period on the southern slope of the Schoharie valley.

Sculpture of the plateau.—In a terrane consisting of strata which dip at varying and perhaps very high angles, the carving out of ranges and production of ravines and gaps may generally be assigned to the occurrence of flexures, of dykes or faults, or of beds whose material is unusually soft, fragile, or rich in minerals of easy decomposition. But the problem of topographical sculpture is less easily solved in a stratum like that of the Catskills consisting of a regular succession of layers which are horizontally homogeneous and from which the phenomena of disruption are absent. The original disintegration and erosion of the mass which resulted in the production of the ranges was perhaps mainly influenced by the direction of the jointage. With this the trend of the ranges in the vicinity of the Kaaterskill Clove appears to

coincide. The ravines, cloves, and deepest notches and valleys may be attributed to the streams of the present hydrographical basins, or to those connected with the ancient eastward and south-eastward inclination of the stratum already considered. But recent observations on the juxtaposition and coincidence of the highest gaps in successive parallel ranges may possibly indicate the remnants—in cross-section—of the beds of ancient streams at that level (about 3000 feet); this conclusion, if confirmed, would signify an inclination of the plateau to the N.N.E. (or to the S.S.W.?) at a still earlier period, that immediately succeeding its elevation.

Kames.—In the upper basin of the Kaaterskill, several isolated hills of gravel, etc., occur at an altitude of 1924 feet, especially on the bank of the stream near the head of the Clove, which are probably kames; their materials, though largely angular, show traces of imperfect stratification. Near "Blythewood," on the North branch of the Schoharie creek, a curious conical and steep isolated kame rises 102 feet above the stream, made up of rounded pebbles of the Catskill grit, rarely a foot in length, overlying a layer of coarse moraine. Its elevation above the sea (1944 feet) exceeds that of any other kame yet observed, those of the Fintry Hills in England reaching 1280 feet, and those of the Androscoggin Lakes, in Maine, 1600 feet. A very interesting series of from eight to twelve very low kames—like parallel ridges, often curving, made up of large rounded boulders—was also found to follow the course of the Kaaterskill near Palenville, in the Hudson Valley, at the mouth of the Clove, at an elevation of about 700 feet; these probably mark the course of the sub-glacial stream which issued from the mouth of the Clove. The paper concluded with observations on a deposit of laminated sand underlying the ground moraine: on the feeble erosion of the slopes of the Clove during the period which has elapsed since the close of the Glacial epoch; and on a new section of the strata of South Mountain obtained from a new road-cutting.

DISCUSSION.

Prof. E. C. H. Day observed that one portion of Dr. Julien's remarks reminded him of an idea which had struck him many years ago with regard to the surface geology of a valley on the south coast of England, near Charmouth, in Dorsetshire.

The stream in the valley referred to finds its way to the sea through a narrow pass, which, as attested by the rapid wearing of the coast line and its present configuration, could only have been of (geologically speaking) very recent origin. How the valley could have been drained prior to the existence of this outlet was a question which might be met by various hypotheses, and one of these was that there might have been a slight unequal local change of level, sufficient to have had the effect of tilting the surface of the valley so that its waters were shed then in a direction opposite to that which they now take. This was nothing more than the veriest hypothesis made many years ago, without any subsequent attempt at verification. It may suggest, however, the possibility of such slight local changes occurring, in addition to the greater movements already distinctly recognized, and the desirability of careful investigation to discover whether such may not be traced in the altered direction of streams and in the existence of ancient and unused water courses—even in our own neighborhoods. It may be added that such local tiltings of parts of the earth's crust would necessarily influence the course of subterranean as well as of subærial waters, thus altering the distribution and force of springs at the surface.

Dr. J. S. Newberry stated that the Catskills presented a more complex bit of topography and geology, and one that had been more discussed than perhaps any other of similar area in the country. It was once supposed that these mountains were composed of a single geological formation, which, from this fact, was called the Catskill group; and it was supposed to be a detached table land, deeply carved by erosion. The late Col. Jewett, of Albany, found strata containing Chemung fossils in the Catskills, and from this inferred that the mountains were composed of Chemung strata. Prof. Hall and Prof. Guyot, with their assistants, then made a careful study, running through several years, of the topography and geology of all the surrounding region. Their labors established the fact that the Catskills are not an isolated mountain group, but belong to the Alleghany system and are formed by a series of folds or arches composed of the Chemung and Catskill rocks. Of these folds, the convex arches, as is usually the case, were cracked and broken and, therefore, yielded readily to erosion, while the concave arches, protected and solid, yielded less readily and, in time, by the wearing away of their surroundings, were left in relief, forming ridges with a synclinal structure. Hence it will be seen that the topography of the Catskill region is chiefly the result of erosion.

So far as regards the changes of level from subterranean causes, referred to by Mr. Julien, it would certainly be strange if the foundations of the Catskills were proved to be stable. The old name, "*terra firma*," once applied to the crust of the earth, is a complete misnomer, and it is really a type of instability. Probably throughout the globe local subsidence and elevation are constantly in progress. In the interior of continents we have no evidence or measure of these, but along coast lines the water line tells us that changes are constantly and everywhere taking place, in the relative level of land and sea. About New York the coast is sinking, though very slowly, while further north, in places, it is rising, and Greenland is sinking again. Back from the coast there is no such nilometer, and yet we have no reason to suppose that the earth is more fixed. Some indication is given by the reports of those who dwell in mountainous regions, of changes of level, which have shut from their view that which was before visible or revealed what was before concealed, but these observations have not been made with accuracy and cannot be depended upon.

In a recent paper before the Academy he had shown the vast changes which had occurred along the coast in this vicinity, viz., that the land once stood 600 feet higher than at present: that the Hudson river had then flowed by the city through a channel from 300 to 500 feet deep, now in large part silted up: that the Palisades then stood from 700 to 800 feet above the river: that the Housatonic then flowed through the East river into New York Bay: that a sub-tropical climate then prevailed throughout this region, with a varied and rich fauna and flora, extending up even to the Arctic Sea: that then a depression of the temperature and great change in the climate ensued, with a corresponding alteration of the fauna and flora; but that these changes were very slow and progressive—the snows, which at first rested temporarily upon the Catskill Mountain summits, became at last permanent, and resulted in local glaciers. These glaciers produced extensive erosion, cutting the channels along which they moved, deeply. A partial obliteration of their work then ensued through two agencies. First, a continental glacier advanced southward, overtopping all the mountains, grinding down the asperities of the surface, fillng old valleys, and banking up a great mass of debris along its margin—a part of which is now Long Island. Afterward, the climate becoming milder, local glaciers were again formed similar to those which preceded the great Glacier, and partially obliterated or modified the results of the ancient erosion. It is a complex problem now to distinguish between the phenomena which have been respectively produced by all these glaciers in varied succession, by the erosion of streams, by flexures of the earth's crust, etc.

The excavating power of glaciers had been denied by Prof. Whitney, but ice, hundreds of feet and sometimes miles in thickness—as it was in the old glaciers—moving

with irresistible force, and having sand, gravel and boulders beneath it, or frozen into it, was the most potent agent of erosion known. The eroding power of the ancient glaciers, which once reached southward to Trenton and Cincinnati, was attested not only by the planed down rocks, but by the immense sheet of transported debris left by the glacier in its retreat.

The glaciated, planed, and polished rocks in the Western States are generally covered by a thick layer of clay, abounding in glaciated boulders. There are also other water-worn materials which have been transported, perhaps thousands of miles, representing the gravel bars, sand beds, etc., produced by sub-glacial rivers. Although the materials are entirely of glacial origin, all the stones are here usually rounded. We find in these deposits, called kames or eskers, the evidences of the action of running water produced by the melting of ice, their accumulation in heaps, ridges, etc., having been effected by local causes, waterfalls, streams upon or under the ice, etc.

The finer material produced by the same grinding action has been deposited along our coast in the vast masses of the Champlain clays. It is well known that the drainage of all glaciers results in milky streams; *e. g.*, those which descend from the Alps impart an opalescence to the Lake of Geneva, and the streams from the Cascade Mountains are clouded with silt derived from the small glaciers at their heads. So, during the Glacial period all the fine material was sometimes washed out of the glacial drift, leaving banks and ridges, kames, hogsbacks, etc., of gravel and boulders, and carried by streams to the coast and there deposited along shore in the Champlain clays. The fine flour and bran ground by the glaciers have been sometimes referred to different epochs, but they are produced simultaneously. The Glacial or Champlain clays are of great economical importance to the city as they are the brick clays of Croton Point, Haverstraw Bay, and other points along the Hudson. Their thickness reaches 100 feet along the lower portion of the Hudson river, 400 feet on Lake Champlain, 500 feet at Montreal, 800 feet at Labrador, 1000 feet at Davis' Strait, and 1800 feet at Polaris Bay. This indicates that the continent was depressed to this extent at each of these points, that the waters of the ocean extended through these valleys, and that here was dead water into which the glacier drainage flowed and was deposited.

In the vicinity of New York City it is evident that the glaciers everywhere overrode and disregarded the underlying topography. All the surface of the island is strewn with materials derived from the N. N. W., and the rock has been planished and striated with grooves running in that direction. The hills back of Yonkers are covered by trap boulders which have been conveyed across the river from the Palisade range on its western side, and it is plain that the Glacier completely disregarded the depression of the Hudson valley, filled it up to a greater or less extent with *debris*, and so rode smoothly over it. Afterwards this and the other valleys were more or less cleared out by the present streams, but a portion of their contents is generally left in their beds, the tunnel between this city and Hoboken being now driven in fact through a part of this clay deposit. On the east side of the city a narrow cañon, 300 to 400 feet deep, has been proved to underlie the East River; and it would have been a wiser and cheaper plan to construct a tunnel through the clay bottom, for communication with Brooklyn, in place of the present costly and to some extent insecure bridge.

Dr. Newberry finally expressed his interest in the careful study of the erosion and sculpture of the Catskills and desire for its continuance.

MRS. J. M. FISKE has left a bequest of $40,000, to establish a hospital for the use of the students of Cornell University.

RINGING FENCES.*

By PROF. S. W. ROBINSON, Ohio State University.

THIS sketch is mainly of a simple fact of observation. My attention was one day suddenly arrested while walking on a hard road alongside a picket fence by the peculiarity of the sound which reached my ear immediately following each step. This sound was first noticed to be very different from that perceived at other parts of the sidewalk. On instituting an inquiry for the cause of this difference the only one discoverable was a change in the construction of the yard fences along the sidewalk.

The peculiarity observed in change of sound was very marked when passing from a portion of the sidewalk opposite a board fence to parts opposite a picket fence. In the former position a quick drop of the foot upon the walk was accompanied by a simple sound or noise of short duration. But when opposite the picket fence the noise following each footstep was prolonged into a curious musical tone of initial high but rapidly lowering pitch, and with a duration of perhaps a quarter of a second.

This singular musical tone following, and due to the noise of a simple foot step, could only be accounted for on the supposition that each picket of the fence reflected the sound reaching it from the foot, the rapid succession of which, from the several pickets of the fence, resulted in the sound observed.

The duration of the sound reflected from the pickets at each step is evidently due to the different distances of the pickets from the ear of the observer, and the greater length of time required for the sound to travel to and from the more distant pickets. For instance, suppose the observer is walking along a stone or mastic walk at a a distance of eight feet from the fence, the latter extending either way some distance along the street. The sharp noise of the footsteps returns from the nearest pickets first. Here the differences in distance from the adjacent pickets is slight, and hence the succession of reflected noises is rapid. But from more remote pickets the difference of distance is greater, and the succession in reflection less rapid.

In studying the nature of the resulting tone it is at once seen that the initial pitch is due to an almost infinite number of reflections or vibrations per second, while at the end of a quarter, or half, second the lines of advance and return of the sound are nearly parallel to the fence, and hence the pulsations have an interval of time equal twice the constant distance between pickets divided by the velocity of sound. For instance, if the pickets be four inches apart, or one-third of a foot, the terminal pitch would be one of about 1500 vibrations per second. The law of retrogression of pitch may be of interest. To express it as a function of passing time, let

d = distance from observer to fence.
a = constant distance between pickets.
v = velocity of sound.
n = number of vibrations per second.
t = the time following the initiation of the reflected tone.

Then by aid of a diagram we easily obtain the following relation between the above quantities, viz.:

$$\frac{v^2}{4\,a^2\,n^2} = 1 - \frac{d^2}{(v\,t + d)^2}$$

The curve for this equation is not easily classified. But by computing quantities and constructing a curve it is found to be very much like a hyperbola referred to its asymptotes, which indicates that the pitch falls rapidly at first, and less so subsequently.

Not only is the above described phenomenal reflection observed in connection with fences, but from any series of flat surfaces in steps, as, indeed, in the case of stairs under proper conditions. Such echoes have been observed from the steps in front of the State House, at Columbus, O.

*Read at A.A.A.S., Cincinnati.